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FROM THE FIRE TO THE FRYING PAN

A THREE-PART STUDY

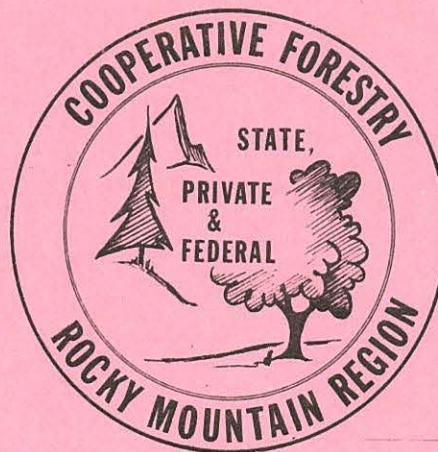
FOR THE

WOOD PRODUCTS INDUSTRY

PROVIDING INFORMATION

ON THE

PROFITABLE RECOVERY OF MILL RESIDUES



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ROCKY MOUNTAIN STATION

Rocky Mountain Region
Forest Service, U. S. Department of Agriculture
Denver, Colorado

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FOREWORD

This report has two objectives. First, it was compiled to provide mill owners with information which can be used to increase profits. Second, it offers an opportunity for better conservation and utilization of valuable wood fibre.

For the area of Southeastern Wyoming, the Black Hills of South Dakota and Wyoming, and the State of Colorado it answers questions such as:

- . . How much mill residue is available?
- . . What are the costs of hauling residue?
- . . Can I profit from chipping?

The following agencies and organizations contributed much of the information contained in this analysis:

State Foresters of Colorado, South Dakota and Wyoming
USFS, Region 2, Division of Timber Management
USFS, Region 2, Division of Engineering
Rocky Mountain Forest and Range Experiment Station
Pacific Northwest Forest and Range Experiment Station
Colorado State University
Colorado, Wyoming, and South Dakota sawmills
Denver and Rio Grande Railroad
Internal Revenue Service
Equipment manufacturers (debarking and chipping)
Western Wood Products Association
Canadian Forest Products Lab (Vancouver, B.C.)
Western South Dakota Traffic Bureau (Rapid City)
Forest Products Laboratory (Madison, Wisconsin)

Sawmill operators are faced with new and more restrictive State air quality regulations. Because of this, they are trying to modify tepee burners to bring them up to standards or, as an alternative, to channel their mill residues into useful products. The following three-part study provides information to help with the latter -- getting wood residues from the fire to the "frying pan" of useful products.

HOW MUCH RESIDUE IS AVAILABLE?

Introduction

While chipping diverts slabs and edgings into useful products, there is a need to utilize other mill residues. To encourage use of by-products of lumber production, the amount and general location of these residues are listed for the Colorado-S.E. Wyoming and Black Hills areas. Comparisons can be made between residue amounts available at potential processing points and raw material requirements of potential products.

Procedure

The areas considered for this study are the same for chipping, except for that part of Colorado south of Highway 50 which is included in the Colorado-Southern Wyoming area. This area is included so that mill residues other than chips could be processed at Durango and/or Monte Vista.

Residue information has been broken down by mill-size class.

All Larger Producers

Annual lumber production by species was determined for mills producing over 5 million bd. ft. per year. These are mills that operate consistently and provide the most dependable source of residue.

Since residue yield factors are usually calculated separately by log breakdown method (see Table 1), the type of head-rig and resaw have been identified for each mill.

Yield factors were determined for bark, sawdust, shavings, trim, and slabs and edgings (see Table 1). One set of factors applies to ponderosa pine and another set to Engelmann spruce, subalpine fir, and lodgepole pine. No attempt was made to develop separate factors for board mills and dimension mills. See Table 2 for derivation of Engelmann spruce, subalpine fir, and lodgepole pine bark factors.

The yield factors (oven-dry tons/M board ft. lumber tally) were then applied against individual mill production by species to determine tons of residue. Some factors were modified slightly to fit mill equipment. Tonnage figures for slabs and edgings do not include material going into chips.

Next, residue tonnage for individual mills was grouped under seven potential processing points (see Table 3). Inactive mills shown for Monte Vista and Montrose (Colorado) are not included in the totals for these two areas. Bark volumes from two post and pole plants (one each in

Custer and Spearfish, S. Dakota areas) are included in the totals.

Potential processing points were chosen for the following reasons:

- 1 - One or more large mills.
- 2 - Centralization in respect to residue volumes.

Other factors would be considered if a processing point were actually established. These are: available labor, freight cost of finished product, average weighted cost/ton of residues f.o.b. processing plant, raw material requirements for product manufactured, etc. Because of these reasons, for example, final choice of a processing point might be Laramie, Wyoming instead of Walden, Colorado, or Kremmling, Colorado rather than Eagle.

Smaller Producers

Residue volumes from mills smaller than 5.0 million bd.ft./year were then added to volumes from the larger mills. The following method of selection was used:

1. Nineteen mills in the Colorado-SE Wyoming area with individual annual productions of from 2.5 MM bd.ft. - 5.0 MM bd.ft. were selected.
2. Mills in the Black Hills of Wyoming and South Dakota with individual annual productions of 1.0 MM bd.ft. - 5.0 MM bd.ft. were selected. Smaller mills than in the Colorado-SE Wyoming area were selected because they are less scattered, and hauling mill residues would be less expensive. Seven mills and two post and pole plants met the production requirements for this category.

3. Individual mills were grouped under the potential processing areas shown in Table 3.
4. Annual lumber production was totaled for each processing area.
5. Modified residue yield factors were applied to the volumes obtained in #4. Factors for larger producers shown in Table 1 are modified for smaller producers as follows:

Colorado-SE Wyoming

Bark - - - - .32 (ave. of ES, LP, AF)

Sawdust - - .25 (factor for circle head-rigs)

Shavings - - .22 (same as for larger mills)

Trim - - - - .14 (same as for larger mills)

*Slabs and
edgings - .38 (pulp chip factor for circle head-rigs)

Black Hills

Bark - - - - .26 (ave. of all log breakdown methods)

*Sawdust - - .61 (ave. of circle head-rigs)

*Shavings - - .34 (ave. of circle head-rigs)

*Trim - - - - .17 (ave. of circle head-rigs)

*Slabs and
edgings - .52 (ave. of circle head-rigs)

*Circle head-rig factors used because most small mills have this type of log breakdown.

The above modified factors were used since no data were available for annual production by timber species or log breakdown methods.

Table 1

RESIDUE YIELD FACTORS
FOR MILLS WITH 5 MM+ ANNUAL PRODUCTION
(Oven-dry tons/M b.f. lumber tally)

Species	Mill Equipment	Bark	Sawdust	Shavings	Trim	Slabs & Edgings	Pulp Chips
PP ↓	Circle head-rig, no resaw	.28 ¹ / ₁	.76 ¹ / ₁	.34 ¹ / ₁	.15 ¹ / ₁	.55 ¹ / ₁	(approx. equal to total of trim and slabs & edgings factors)
	Circle head-rig, gang resaw	.22 ¹ / ₁	.57 ¹ / ₁	↓	.18 ¹ / ₁	.42 ¹ / ₁	
	Circle head-rig, horizontal band resaw	.29 ¹ / ₁	.50 ¹ / ₁	↓	.19 ¹ / ₁	.59 ¹ / ₁	
	Band head-rig, all resaws	<u>2,5,6</u> / .25	<u>2,5,6</u> / .26	<u>2,5,6</u> / .12	.17 ¹ / ₁	<u>2,5,6</u> / .32	
ES,AF,LP ↓	Chipper head-rig	<u>3,7</u> / .31-ES .36-AF .28-LP	.10 ³ / ₁	.22 ⁴ / ₁	.14 ¹ / ₁		.71 ³ / ₁
	Band head-rig, gang resaw	↓	.18 ³ / ₁	↓	↓		.35 ³ / ₁
	Circle head-rig, gang resaw	↓	.25 ³ / ₁	↓	↓		.38 ³ / ₁
	Scragg mill	↓	.41 ³ / ₁	↓	↓		.56 ³ / ₁

Note: Trim factor for ES, AF, & LP was reduced from Black Hills factor.

1,2,3,4,5,6,7 - Sources shown on next page.

SOURCES (for Table 1)

1. Landt, E. F. and Woodfin, R. O., Jr.

1964 Sawmill and logging residues from Ponderosa pine trees in the Black Hills. USFS Rocky Mountain Forest & Range Experiment Station, Res. Note 23, 8 pp, illus.

2. U. S. Forest Survey.

1966. Computed estimates of residue recovery from Ponderosa pine in a band mill. Unpublished data, Rocky Mountain Forest and Range Experiment Station.

3. J. Dobie - Canadian Forest Products Lab., Vancouver, B. C.

4. Joe Kerscher - Kaibab Lumber Co., Littleton, Colorado

5. Corder, S. E.

1956. Oregon mill residues in 1953. Oregon State University Forest Products Lab., Inform. Circ. 7, 32 pp, illus.

6. Voorhies, Glenn

1942. An inventory of sawmill waste in Oregon. Oregon State University Forest Products Lab. Bull. Series 17, 52 pp, illus.

7. Smith, J. H. G. and A. Kozak.

1967. Thickness and percentage of bark of the commercial trees of British Columbia. U.B.C. Faculty of Forestry, Vancouver, B.C.

Table 2BARK YIELD FACTOR CALCULATIONS

	<u>Engelmann Spruce</u>	<u>Sub-Alpine Fir</u>	<u>Lodgepole Pine</u>
* Cu. ft./M L.T.	22	23	17
** Lbs./cu. ft. (oven dry)	28	31	33
Lbs./M L.T.	616	713	561
Dry tons/M L.T.	.31	.36	.28

* These volumes were developed from Source #7 listed on page 6.

** These weights were obtained from Source #3 listed on page 6.

Sub-Alpine Fir and Lodgepole Pine factors are actually Balsam Fir and Jack Pine, respectively. Canada had no factors for either Sub-Alpine Fir or Lodgepole Pine.

Figure 1 shows potential processing centers and satellite sources for mill residues in Colorado, southeastern Wyoming, and the Black Hills of South Dakota and Wyoming.

Denver, Colorado and Rapid City, South Dakota are shown as potential processing centers, although they are not shown in Table 3. These two points may be well suited as potential processing points for particleboard.

Raw material requirements for several processing plants of minimum economical size are shown in Table 5.

Total residue tonnage by potential processing centers, summarized from Table 3, is shown in Table 4. Residue totals in Table 4 are gross for the Colorado-SE Wyoming area and net (after deducting volume being sold or used) for the Black Hills.

- Potential Processing Centers for Mill Residue
- Satellite Sources for Mill Residue

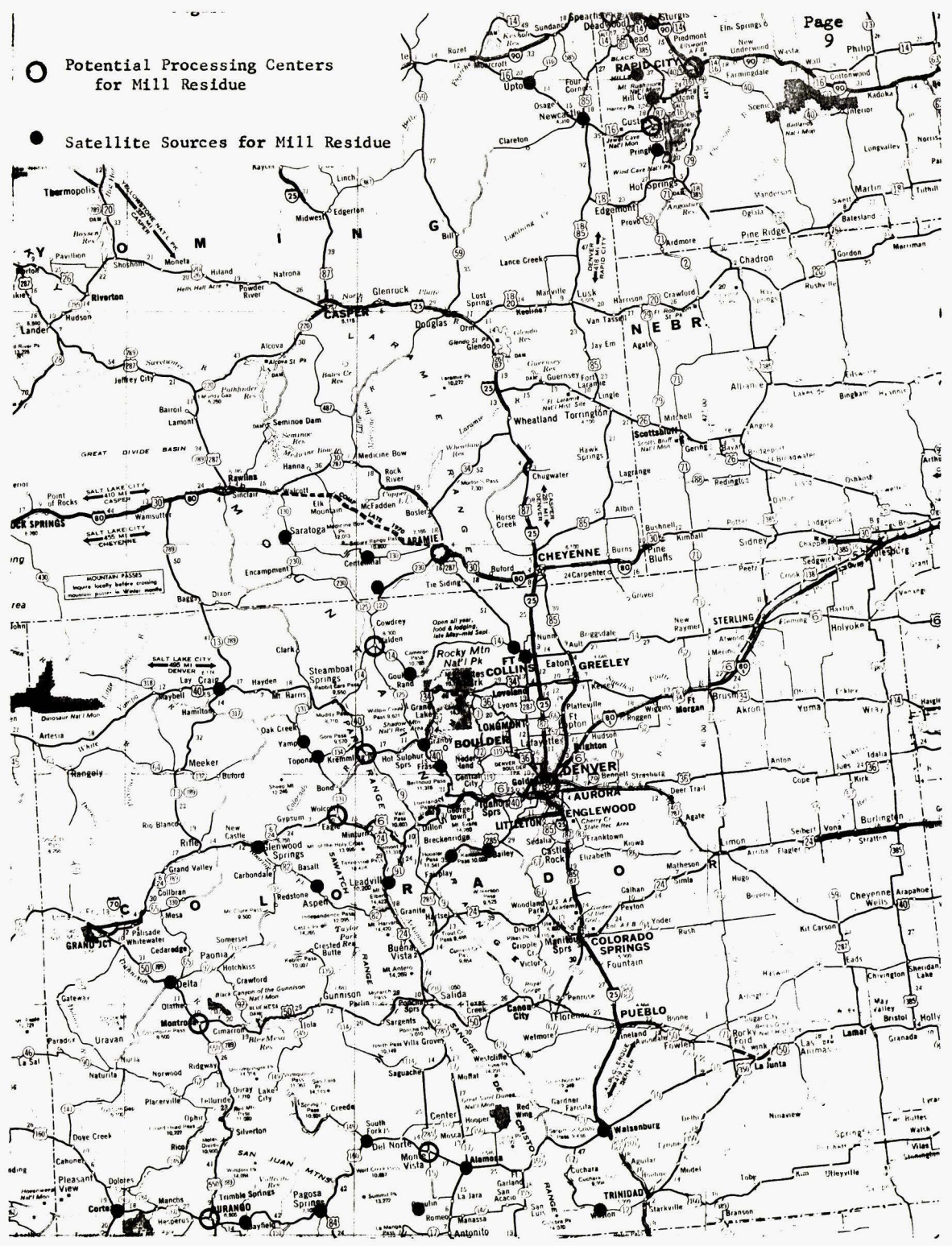


Table 3

(2/1/72)

Annual Mill Residues
(oven-dry tons)
by potential processing points

Area #	Area and Mill Production Range	Free Bark	Attached Bark	Slabs and Edgings, Bark-Free	Slabs and Edgings, Bark-Attached	Shavings	Trim	Sawdust
<u>Colorado</u>								
A	<u>Monte Vista</u>							
	5.0 MM+	13,468	--	--	--	9,306	5,922	7,614
	2.5MM-5.0MM	--	3,200	--	3,800	2,200	1,400	2,500
	Total	13,468	3,200	--	3,800	11,506	7,322	10,114
	* Inactive-(5.0 MM+)	(4,725)	(1,590)	--	(2,000)	(4,400)	(2,800)	(5,250)
B	<u>Durango</u>							
	5.0 MM+	11,375	16,521	--	19,201	13,204	9,264	15,820
	2.5MM-5.0MM	--	2,400	--	2,850	1,650	1,050	1,875
	Total	11,375	18,921	--	22,051	14,854	10,314	17,695
C	<u>Montrose</u>							
	5.0 MM+	6,391	--	2,023	--	4,492	2,819	5,280
	2.5MM-5.0MM	--	5,120	--	6,080	3,520	2,240	4,000
	Total	6,391	5,120	2,023	6,080	8,012	5,059	9,280
	* Inactive-(5.0 MM+)	(6,020)	(2,040)	--	(2,280)	(5,950)	(3,720)	(7,140)
D	<u>Eagle-Kremmling</u>							
	5.0 MM+	2,544	5,132	--	6,200	5,654	3,598	5,835
	2.5MM-5.0MM	--	5,472	--	6,498	3,762	2,394	4,275
	Total	2,544	10,604	--	12,698	9,416	5,992	10,110
E	<u>Walden-Laramie</u>							
	5.0 MM+	16,052	6,657	--	8,766	17,072	10,864	16,202
	2.5MM-5.0MM	--	1,600	--	1,900	1,100	700	1,250
	Total	16,052	8,257	--	10,666	18,172	11,564	17,452
<u>South Dakota</u>								
F	<u>Custer</u>							
	5.0 MM+	15,340	--	--	--	20,740	10,500	24,810
	1.0MM-5.0MM	598	1,742(	to 520	3,484	2,618	1,309	4,697
	Total	15,938	1,742(chips	520	3,484	23,358	11,809	29,507
G	<u>Spearfish</u>							
	5.0 MM+	14,070	--	2,100	--	14,220	10,050	20,550
	1.0MM-5.0MM	2,210	572	2,080	1,144	2,108	1,054	3,782
	Total	16,280	572	4,180	1,144	16,328	11,104	24,332

* Not included in totals.

Summary of Table 3
Colorado-SE Wyoming

Table 4

	<u>Monte Vista</u>	<u>Durango</u>	<u>Montrose</u>	<u>Eagle- Kremmling</u>	<u>Walden- Laramie</u>
Sawdust	10,114	17,695	9,280	10,110	17,452
Shavings	11,506	14,854	8,012	9,416	18,172
Subtotal	21,620	32,549	17,292	19,526	35,624
Coarse residue (S&E, trim)	11,122	32,365	13,162	18,690	22,230
Subtotal	32,742	64,914	30,454	38,216	57,854
Bark	16,668	30,296	11,511	13,148	24,309
Totals	49,410	95,210	41,965	51,364	82,163

Black Hills

	<u>Custer</u>	<u>Spearfish</u>
Sawdust	29,507	24,332
*Used or sold	400	600
Net	29,107	23,732
Shavings	23,358	16,328
*Used or sold	4,420	450
Net	18,938	15,878
Net subtotal	48,045	39,610
Coarse residue (S&E, trim)	15,813	16,428
*Used or sold	2,180	3,000
Net	13,633	13,428
Net subtotal	61,678	53,038
Bark (none used or sold)	17,680	16,852
Totals	79,358	69,890

*As determined by the South Dakota Dept. of Forestry for mills with annual production over 1.0 MM bd.ft. These figures do not include material given away.

Table 5

RAW MATERIAL REQUIREMENTS
FOR ALTERNATIVE FORMS
OF RESIDUE UTILIZATION

Type of Plant	Production (finished product)	Annual Raw Material Requirements	Source
Electrical utility-- steam generated	1 million lbs./hr. of 1,000°F steam (enough for city of Grand Jct, Colo.)	1.7 million tons of bark (green)	1
*Pulp mill (sulfate)	207,000 tons of pulp per year	497,000 tons (oven-dry)	2,3,4
*Particleboard (standard)	52.1 million sq.ft. (3/4" basis)	62,500 tons (oven-dry)	5
*Particleboard (specialized)	20.8 million sq.ft. (3/4" basis)	25,000 tons (oven-dry)	5
*Charcoal	2,500 tons of briquettes/yr.	8,000 tons (oven-dry)	6
*Wood fuel briquettes (2 machines)	5,000 tons of 8 lb. logs/yr.	5,000 tons (10% M.C.)	7
*Bedding for 600,000 feedlot cattle in NE Colorado	at 16 lbs./day/cow = 4800 tons/day = 1,752,000 tons/yr.		8
*Residue requirements <u>aren't</u> shown by <u>type</u> of residue (sawdust, shavings, etc.) needed.			

SOURCES (for Table 5)

1. 1971. Koch and Mullen; Bark from southern pine may find use as fuel;
Forest Industries, April 1971.
2. Mr. Auchter; Forest Products Laboratory, Madison, Wisconsin.
3. Pulp Manufacturing Information; WFPR-89 (rev. July 1962); Forest Products Lab.
4. 1964. Pulp yields for various processes and wood species; FPL-031; Forest
Products Laboratory.
5. 1971. Feasibility of establishing particleboard plants in the Four Corners
Economic Development Region, New Mexico State University.

6. 1965. Dost; Wood residue uses in the California pine region; Calif. Agr. Experiment Station Bulletin 817.
 7. 1966. Wood Briquettes, Inc., Lewiston, Idaho.
 8. 1967. Unpublished Colo. State University study of Cook Lumber Co., Fort Collins, Colorado.
-

Conclusions

A comparison of the foregoing data with residue volumes shown in Table 4 indicates that, for mill residue only, there is enough volume for at least:

- - 2 standard particleboard plants in the Black Hills
- - 4 specialized particleboard plants in the Black Hills
- - 4 charcoal plants at Custer, South Dakota
- - 4 charcoal plants at Spearfish, South Dakota
- - 1 standard particleboard plant at Durango
- - 1 standard particleboard plant in the Walden-Laramie area

WHAT ARE COSTS OF HAULING RESIDUE?

Procedure

Haul rates were determined to provide cost estimates for transporting residues to potential processing points.

Truck freight rates only were determined for residue hauls under 150 miles (see Table 6).

Using Table 6, truck freight rates from residue concentration points to Denver and Rapid City were also determined. (See Table 7 and Figure 1).

Railroad freight rates from four concentration points in Colorado were obtained from the Denver and Rio Grande Railroad (see Table 8).

Weights per cu.ft. for sawdust and shavings were determined for estimating hauling costs in situations where only the cu.ft. capacity of the carrier is known.

Results

13-ton van rates for 10-150 mile hauls ranged from 7.7¢/ton mile to 11.5¢. For 23-ton vans, the rate ranged from 5.5¢ to 8.0¢/ton mile.

A comparison of Tables 7 and 8 shows the cost savings of a RR haul into Denver. For instance, the cost savings of railroad over truck from Eagle is \$6.03/ton. Costs of loading, unloading, or storage were not calculated for either method of transportation.

It was assumed that truck versus railroad hauling within the Black Hills would be cheaper because of the relatively short hauling distances involved.

Weights per cu. ft. are shown below as an aid in estimating hauling costs. Weights are oven-dry unless otherwise noted.

	<u>Ponderosa pine</u>	<u>Spruce, fir, lodgepole</u>
Solid wood	26.0 lbs./cu.ft. ^{<u>1/</u>}	22.5 lbs./cu.ft. ^{<u>2/</u>}
Shavings (10% M.C.)	9.0 lbs./cu.ft. ^{<u>3/</u>}	7.4 lbs./cu.ft. ^{<u>4/</u>}
Sawdust	10.4 lbs./cu.ft. ^{<u>1,2,5/</u>}	9.0 lbs. cu.ft. ^{<u>1,2,5/</u>}
Sawdust - all spp. (35% M.C.)	Packed - 20.0 lbs./cu.ft. ^{<u>1/</u>} Unpacked - 16.0 lbs./cu.ft. ^{<u>1/</u>}	

1. Rocky Mountain Forest and Range Experiment Station
2. Forest Products Laboratory, Vancouver, Canada.
3. Wood Briquettes; Lewiston, Idaho.
4. Joe Kerscher; Kaibab Lumber Co.; Littleton, Colorado.
5. Forest Products Laboratory, Ottawa, Canada.

Table 6

(3/7/72)

Truck Haul Rates

*(13-ton van)

<u>One-way Distance</u>	<u>Rate/mile loaded</u>	<u>Rate/ton mile</u>	<u>Rate/ton</u>
10	\$ 1.50	11.5¢	\$ 1.15
15	1.40	10.7¢	1.60
25	1.13	8.7¢	2.17
50	1.04	8.0¢	4.00
75	1.01	7.7¢	5.78
100	1.00	7.7¢	7.70
125	1.00	7.7¢	9.62
150	1.00	7.7¢	11.55

*Based on 1971 Oregon State University study and modified by Kaibab Lumber Co. and Western Traffic Bureau (Rapid City, South Dakota) haul rates.

**(23-ton van)

10	\$ 1.04	8.0¢	\$ 0.81
15	1.00	7.7	1.15
25	.82	6.3	1.58
50	.75	5.8	2.90
75	.73	5.6	4.20
100	.72	5.5	5.50
125	.72	5.5	6.87
150	.72	5.5	8.25

** Based on 1971 OSU study.

Table 7

(3/7/72)

Cost of Hauling Residue into Denver

(13-ton van)

<u>From</u>	<u>To</u>	<u>Distance</u>	<u>Cost/ton</u> <u>(truck only)</u>
Ft. Collins	Denver	65 miles	\$ 5.07
Kremmling	Denver	115 miles	8.85
Walden	Denver	136 miles	10.47
Eagle	Denver	138 miles	10.63
Monte Vista	Denver	218 miles	16.79
Montrose	Denver	270 miles	20.79

Cost of Hauling Residue into Rapid City

(13-ton van)

<u>From</u>	<u>To</u>	<u>Distance</u>	<u>Cost/ton</u> <u>(truck only)</u>
Custer	Rapid City	42 miles	\$ 3.44
Spearfish	Rapid City	52 miles	4.16
Newcastle (Wyoming)	Rapid City	80 miles	6.16
Hulett (Wyoming)	Rapid City	107 miles	8.24

Table 8

(3/7/72)

RR Freight Rates to Denver

(Sawdust, Bark, Sawmill refuse)

From: Kremmling, Colo. - 152 RR miles.

<u>lbs. minimum</u>	<u>rate/100 lbs.</u>	<u>cost/ton</u>
45,000	18¢	\$ 3.60
65,000	17¢	3.40
90,000	15¢	3.00

Eagle, Colo. - 190 RR miles.

45,000	23¢	4.60
65,000	19¢	3.80
90,000	17¢	3.40

Monte Vista, Colo. - 261 RR miles

45,000	34¢	6.80
65,000	27¢	5.40
90,000	22¢	4.40

Montrose, Colo. - 370 RR miles

45,000	41¢	8.20
65,000	32¢	6.40
90,000	28¢	5.60

Note: Recent RR freight increases since Nov. 19, 1970, do not apply in Colorado.

CAN I CHIP?

Introduction

Sawmill operators have probably asked themselves this question many times. To help answer the question, chipping feasibility has been determined for mill operators in the Colorado, Southeastern Wyoming and Black Hills areas.

Pulp chips are only one of several markets for mill residues consisting of slabs, edgings, and trim. Other markets for chippable residue are particleboard, bedding, fuel, etc.

Gross chip revenue and variable and fixed debarking-chipping costs at five investment levels are shown on break-even charts. A method for individual mills to determine their break-even point is shown.

The feasibility of debarking and selling slabs is at an investment level of \$20,000.

The current chip situation for each area is summarized as follows.

Procedure

The chip study area was limited to:

1. That part of Colorado north of Highway 50 and west of Interstate 25. No mills exist east of I-25. Chip mills south of Highway 50 could ship to the pulp mill at

Snowflake, Arizona. No data were collected on prices or freight for chips going to Snowflake. The freight situation in this area, however, differs from transportation costs of chips bound for Wisconsin.

2. Southeastern Wyoming - because of the four major mills concentrated in that area.
3. Black Hills of Wyoming and South Dakota - because of the concentration of mills in that area.

Data were collected only from mills with over 5 million board feet annual production. Few mills with less production are chipping, either because of high freight costs or a feeling that investments cannot be recovered.

Data were collected from industry on chip and lumber production, chip freight, gross chip revenues, cost of debarking and chipping equipment and labor involved in debarking and chipping. Chip revenues and freight rates are shown on a 2400-lb. Bone Dry Unit basis.

Calculated costs are shown in Table 9. They apply to both the Black Hills and the Colorado-SE Wyoming area.

Calculated variable costs are shown in Table 10. The net variable costs are shown in the break-even graphs. Freight costs include trucking, loading, and unloading.

Fixed costs, variable costs, total costs, and revenue are shown in Table 11 and on break-even graphs for investment levels of \$50,000, \$100,000, \$150,000, \$200,000, and \$250,000. Since revenues and costs vary by area, a separate set of graphs was made for the Black Hills area and the Colorado-Southeastern Wyoming area (see Graphs 1-10).

Uses of break-even charts show:

- production needed to break-even.
- profit by production level.
- how changes in revenues or costs change the break-even point.

Limitations of break-even charts assume:

- that all variable costs remain the same.
- that increased production won't affect unit revenue.

Break-even points in units (2400 lbs. BDU) were taken from the charts and listed in Table 12. These units were converted to annual bd. ft. lumber production break-even points by using the unit/M bd. ft. conversion ratios for each area.

For individual mills, the break-even point in units (Y) can be calculated as follows:

$$\text{Fixed cost} + (\text{unit variable cost} \times \text{number of units}) = \text{gross unit revenue} \times \text{number of units}$$

Example:

Fixed cost = \$20,000

Variable cost = \$25.00 unit

Sales volume = 9,000 units

Gross revenue per unit = \$34.00

Profit = \$306,000 revenue less \$20,000 fixed cost and \$225,000 variable cost

$$\$20,000 + 25Y = 34Y$$

$$20,000 = 34Y - 25Y$$

$$= 9Y$$

$$Y = \frac{20,000}{9}$$

$$= 2,222 \text{ units}$$

The feasibility of debarking and selling slabs is shown in Table 13.

The current chip situation in the Black Hills and the Colorado-Southeastern Wyoming area is shown in Table 14.

Conclusions

The average weighted revenue/2400# Bone Dry Unit in 1971 is \$33.31 in the Black Hills and \$36.03 in Colorado-Southeastern Wyoming (see Table 11).

Annual fixed costs range from \$7,238 at the \$50,000 investment level to \$36,288 at the \$250,000 investment level (see Table 9).

Net variable costs/unit range from \$20.90 to \$24.56 in the Black Hills and from \$26.54 to \$30.20 in the Colorado-SE Wyoming area (see Table 10).

The weighted average net revenue per unit (after deduction of all costs) is \$9.46 in the Black Hills and \$6.53 in the Colorado-SE Wyoming area (see Table 11).

Annual lumber production levels at which mills can profitably chip range from 0.9 million bd. ft. to 3.3 million bd. ft. in the Black Hills and from 1.4 million bd. ft. to 5.4 million bd. ft. in Colorado-SE Wyoming (see Table 12).

Although only limited data has been compiled from two mills, it appears that a mill can break even on debarking and selling slabs if the cost of the debarker and installation is \$20,000 or less (see Table 13).

68,115 units of chips are being shipped annually from the Black Hills to Wisconsin pulp mills.

82,975 units are shipped annually out of the Colorado-SE Wyoming area. 32,000 of these units are shipped to Snowflake, and the remainder to Wisconsin.

Four additional mills in Colorado-SE Wyoming plan to start chipping in 1972.

Table 9Chip Production Costs-Annual

(Fixed)

Source	Cost Item	Investment Levels				
		\$50,000	\$100,000	\$150,000	\$200,000	\$250,000
	<u>Fixed:</u>					
1	Equip. salvage value @ 7% (of cost)	3,500	7,000	10,500	14,000	17,500
	Net amount to depreciate	46,500	93,000	139,500	186,000	232,500
2	Equip. depreciation (10-yr. schedule, straight-line)	4,650	9,300	13,950	18,600	23,250
1 & 3	Average investment $\frac{(I-R)(N+1)}{2N} + R$	29,075	58,150	87,225	116,300	145,375
	I = purchase + install. cost					
	R = salvage value					
	N = expected useful life					
1	Property tax 1.3% of ave. investment					
1	Insurance 1.6% of ave. investment					
1	Interest (on income foregone) 6% of ave. investment					
	Total - 8.9%	2,588	5,175	7,763	10,351	13,038
<u>Total Annual Fixed Cost</u>		\$ 7,238	\$ 14,475	\$ 21,713	\$ 28,951	\$ 36,288

Note: Investment levels above are the installed costs of debarker, chipper, and auxiliary equipment.

Table 10Chip Production Costs-Annual

(Variable)

Source	Cost Item	Investment Levels				
		\$ 50,000	\$100,000	\$150,000	\$200,000	\$250,000
	Average annual mill production units (MM)	2950(7.0)	8750(11.5)	8767(15.6)	11200(20.0)	12405(23.4)
	<u>Variable:</u>					
4	Labor (\$3.00 hr.) Averaged for each investment level.	\$ 14,650	\$ 16,800	\$ 17,667	\$ 28,800	\$ 26,608
1	Payroll taxes and	2,930	3,360	3,534	5,760	5,322
5	insurance (20% of base wages)					
	Total Labor -	\$ 17,580	\$ 20,160	\$ 21,201	\$ 34,560	\$ 31,930
	Total labor cost:					
	Per unit	5.96	2.30	2.42	3.09	2.57
	Per M	2.51	1.75	1.36	1.73	1.36
	<u>Power</u>					
1,5,6	Cost/unit	1.60	1.60	1.60	1.60	1.60
1,4,5	<u>Repairs (no labor)</u>					
	Cost/unit	1.00	1.00	1.00	1.00	1.00
4	Freight/unit (Black Hills)	18.00	18.00	18.00	18.00	18.00
4	Freight/unit (Colo.-Wyo.)	23.64	23.64	23.64	23.64	23.64
	Total variable cost/unit:					
	Black Hills	26.56	22.90	23.02	23.69	23.17
	Colo.-Wyo.	32.20	28.54	28.66	29.33	28.81

(continued on next page)

(Table 10 - continued)

Source	Cost Item	Investment Levels				
		\$ 50,000	\$100,000	\$150,000	\$200,000	\$250,000
1	Costs avoided by					
6	debarking and					
	chipping:					
	Per M	1.00	1.00	1.00	1.00	1.00
	Per unit @ 0.5					
	units/M	2.00	2.00	2.00	2.00	2.00
(deducted from total variable costs of chips)						
<u>Net variable cost/unit:</u>						
	Black Hills	\$ 24.56	\$ 20.90	\$ 21.02	\$ 21.69	\$ 21.17
	Colo.-Wyo.	\$ 30.20	\$ 26.54	\$ 26.66	\$ 27.33	\$ 26.81

- Notes: 1. 1 unit = 2400 bone dry lbs.
2. Freight costs include truck transport to RR siding for some mills.
3. Power and repair costs/unit would ideally decrease with an increase in investment levels. For convenience, an average cost/unit was used for all investment levels.
4. Costs reduced by debarking and chipping are on saw maintenance and wood residue disposal.
5. Sources 1,2,3,4,5,6 shown on following page.

Table 11

Break-Even Chart Data

Source	Revenues and Costs	Investment Levels				
		\$50,000	\$100,000	\$150,000	\$200,000	\$250,000
<u>Black Hills and Colo.-Wyoming</u>						
Annual fixed cost	\$ 7,238	\$ 14,475	\$ 21,713	\$ 28,951	\$ 36,288	
Units produced	5,900	17,500	26,300	11,200	37,215	
*Ave. # units/ mill/yr.	2,950	8,750	8,767	11,200	12,405	
*Average based on 7 mills in Black Hills + 4 in Colo.-Wyo.						
<u>Black Hills -- 6 mills</u>						
4	Weighted ave. chip revenue/unit	33.31	33.31	33.31	33.31	33.31
	Net variable cost/unit	24.56	20.90	21.02	21.69	21.17
	Net revenue/unit (before deducting fixed costs)	8.75	12.41	12.29	11.62	12.14
	Fixed cost/unit (from above)	2.46	1.65	2.48	2.58	2.93
	Net revenue/unit	6.29	10.76	9.81	9.04	9.21

1/ Weighted ave. chip revenue - - - - - 33.31/unit
Determined by: (unit revenue at each mill x units produced
at that mill) ÷ total units produced in each area.

2/ Weighted ave. net variable cost - - - - - 21.34/unit
Determined by: (net variable cost/unit at each investment
level x units produced at that level) ÷ total units produced
at all investment levels in each area.

3/ Weighted ave. fixed cost - - - - - 2.51/unit
Determined by: (fixed cost/unit at each investment level
x units produced at that level) ÷ total units produced at
all investment levels in both areas.

4/ Net revenue (weighted) - - - - - 9.46/unit
Determined by subtracting 2/ and 3/ from 1/.

(Table 11 - continued)

Break-Even Chart Data

Source	Revenues and Costs	Investment Levels				
		\$50,000	\$100,000	\$150,000	\$200,000	\$250,000
<u>Colo.-SE Wyo. - 5 mills</u>						
4	Weighted ave. chip revenue/unit	36.03	36.03	36.03	36.03	36.03
	Net variable cost/unit	30.20	26.54	26.66	27.33	26.81
	Net revenue/unit (before deducting fixed costs)	5.83	9.49	9.37	8.70	9.22
	Fixed cost/unit (from above)	2.46	1.65	2.48	2.58	2.93
	Net revenue/unit	3.37	7.84	6.89	6.12	6.29
5/	<u>Weighted ave. revenue - - - - - 36.03/unit</u>					.
	Determined by: (unit revenue at each mill x units produced at that mill) $\div$ total units produced in <u>each</u> area.					
6/	<u>Weighted ave. net variable cost - - - - - 26.99/unit</u>					
	Determined by: (net variable cost/unit at each investment level x units produced at that level) $\div$ total units produced at all investment levels in <u>each</u> area.					
7/	<u>Weighted ave. fixed cost - - - - - 2.51/unit</u>					
	Determined by: (fixed cost/unit at each investment level x units produced at that level) $\div$ total units produced at all investment levels in <u>both</u> areas.					
8/	<u>Net revenue (weighted) - - - - - 6.53/unit</u>					
	Determined by subtracting 2/ and 3/ from 1/.					

SOURCES (Tables 9, 10 and 11)

1. A Cost Analysis of Chip Manufacture at Hardwood Sawmills, USFS Research Paper, NE-69, 1967.
2. Internal Revenue Service
3. An Appraisal for Salvaging Small Sawmill Residues in the Southeast, USFS Research Paper, SE-84, Nov. 1957.
4. Actual industry experience.
5. 1969 Soderham study for a Colorado sawmill.
6. 1960 WWPAA study on debarkers.

Table 12Break-Even Points - M units/yr.

<u>Investment level</u>	<u>Colo.-SE Wyo.</u>	<u>Black Hills</u>
\$ 50,000	1.3	0.8
100,000	1.5	1.2
150,000	1.9	1.6
200,000	2.7	2.1
250,000	3.3	2.6

*Break-Even Points - MM bd. ft./yr.

<u>Investment level</u>	<u>Colo.-SE Wyo.</u>	<u>Black Hills</u>
\$ 50,000	2.32	1.16
100,000	2.68	1.74
150,000	3.40	2.32
200,000	4.82	3.04
250,000	5.89	3.77

Note: Conversion ratio for Colo.-SE Wyo. - - - - 0.56 units/M

Conversion ratio for Black Hills - - - - - 0.69 units/M

*Calculated by formula:

$$\text{B.E. point (MM bd.ft./yr.)} = \frac{\text{B.E. point (M units/yr.)}}{\text{Conversion ratio}}$$

Table 13Feasibility of Debarking and Selling Slabs

Two sawmills are doing this in the Black Hills. The \$20,000 investment level shown below doesn't especially represent actual mill investment.

Revenue: \$6.25/unit or cord (average)

Costs:

Assuming a \$20,000 investment for debarker, then:

Equipment salvage value @ 7% - - - - -	\$ 1,400
Net amount to depreciate - - - - -	\$ 18,600
Equipment depreciation (10-yr. straight line) - - - - -	\$ 1,860
Average investment - - - - -	\$ 11,630
$\frac{(I-R)(N+1)}{2N} + R$	
Property tax, insurance, interest - 8.9% of ave. investment - - - - -	\$ 1,035
Annual fixed cost - - - - -	\$ 2,895
Ave. production - - - - -	1750 units/yr. (0.7 conv. rate)
<u>Fixed cost/unit</u> - - - - -	\$ 1.65
Labor, taxes, insurance - - - - -	\$ 9,000/yr.
- - - - -	\$ 5.14/unit
Power - - - - -	\$.60/unit
Repairs - - - - -	\$.50/unit
<u>Variable cost/unit</u> - - - - -	\$ 6.24
<u>Total cost/unit</u> - - - - -	\$ 7.89/unit
Costs avoided that are otherwise chargeable to lumber production - - - -	\$ 2.00/unit
Net cost/unit - - -	\$5.89
This leaves \$6.25 - \$5.89 or 36¢/unit for transportation.	

Table 14Current Chip SituationColo.-SE Wyo.

Three sawmills and one plywood plant shipped 32,000 units to Snowflake, Ariz.

Six sawmills shipped - - - - - 50,975 units to Wisconsin

Total - - - - - 82,975 units

Combined lumber production of above mills - - - - - 149.8 MM

Conversion ratio = 0.56 units/M (includes plywood plant)

Weighted ave. chip revenue (mills shipping to Wisconsin) - \$36.02/unit

Weighted ave. freight (mills shipping to Wisconsin) - 23.64/unit

Net revenue - - - - - \$12.38/unit

Four additional sawmills will probably start chipping in 1972.

Black Hills

Seven sawmills shipped 68,115 units to Wisconsin.

Combined lumber production of these mills - - - - - 94.0 MM

Lumber production of 2 mills that sell

debarked slabs - - - - - 5.0 MM

Total - - - - - 99.0 MM

Conversion ratio = 0.69 units/M

Weighted ave. chip revenue - - - - - \$33.31/unit

Weighted ave. freight - - - - - 18.00/unit

Net revenue - - - - - \$15.31/unit

(One sawmill is debarking, but not selling slabs).

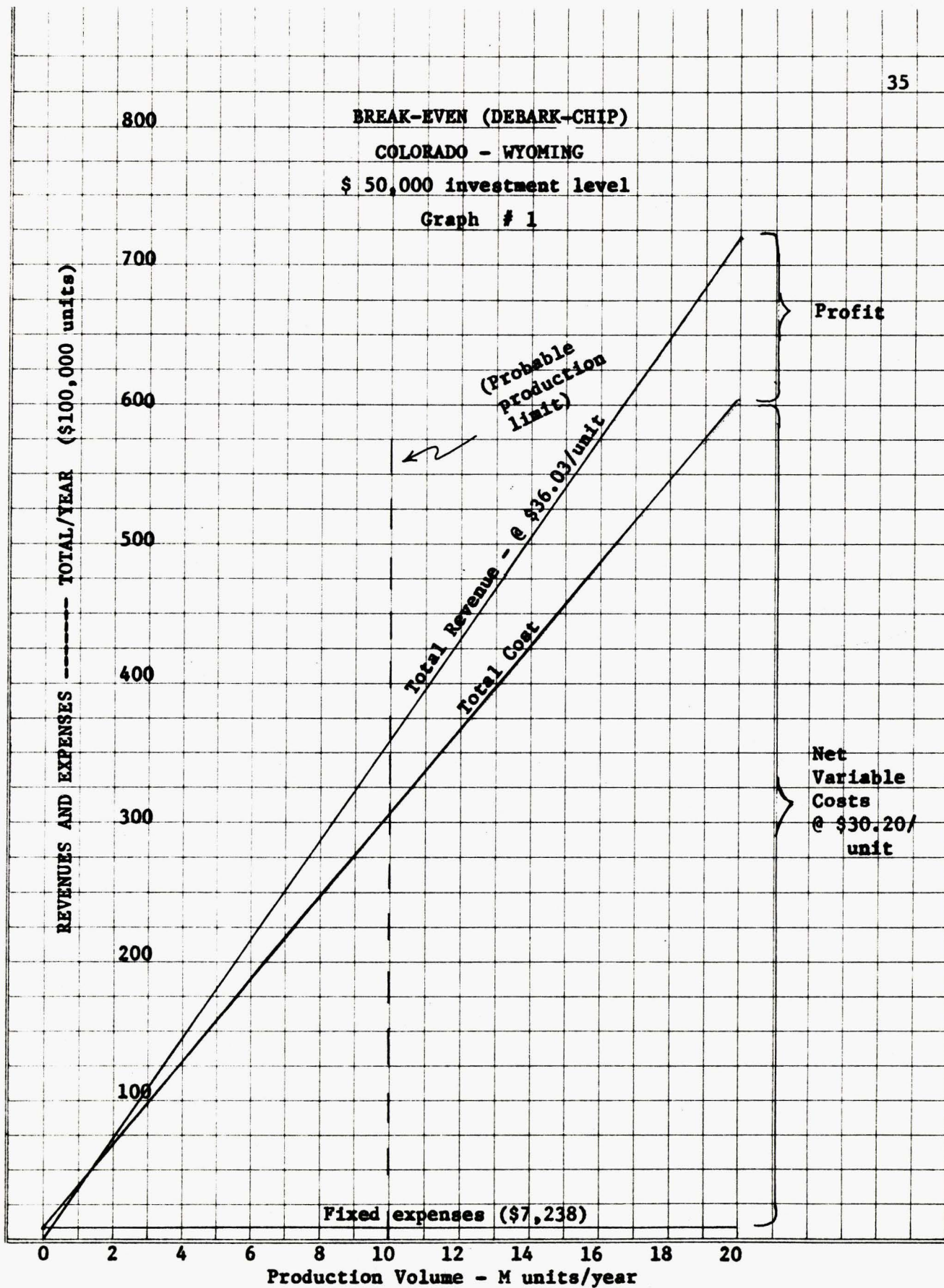
Note: 1 unit = 2400 lbs. bone dry.

OVERALL CONCLUSIONS OF STUDY

From the break-even points developed, it appears that smaller mills not now chipping could do so at a profit. One cost that was not included in the study was demurrage charges accrued when RR cars stand idle on a siding for several days. This cost would be greater per unit with the smaller mills.

There is no potential processing point where enough residues are available for particleboard manufacture. In every case, residues must be hauled in from outside the point. It is felt that this can be done economically, however.

A recent study of particleboard plant feasibility in New Mexico showed that a plant paying \$5.65/ton for residue transportation could operate at a profit. If this cost were applicable to the Black Hills, residue could be economically trucked into Rapid City from all points except Hulett, Wyoming. At \$5.65 per ton, trucking into the Denver area would be economically feasible only from Fort Collins. However, residue could be profitably shipped by rail from Eagle, Kremmling, and possibly Monte Vista.



BREAK-EVEN (DEBARK-CHIP)

COLORADO - WYOMING

\$ 100,000 investment level

Graph # 2

(Probable production limit)

REVENUES AND EXPENSES
TOTAL/YEAR (\$100,000 units)

800

700

600

500

400

300

200

100

Profit

Net
Variable
Costs
@ \$26.54/
unit

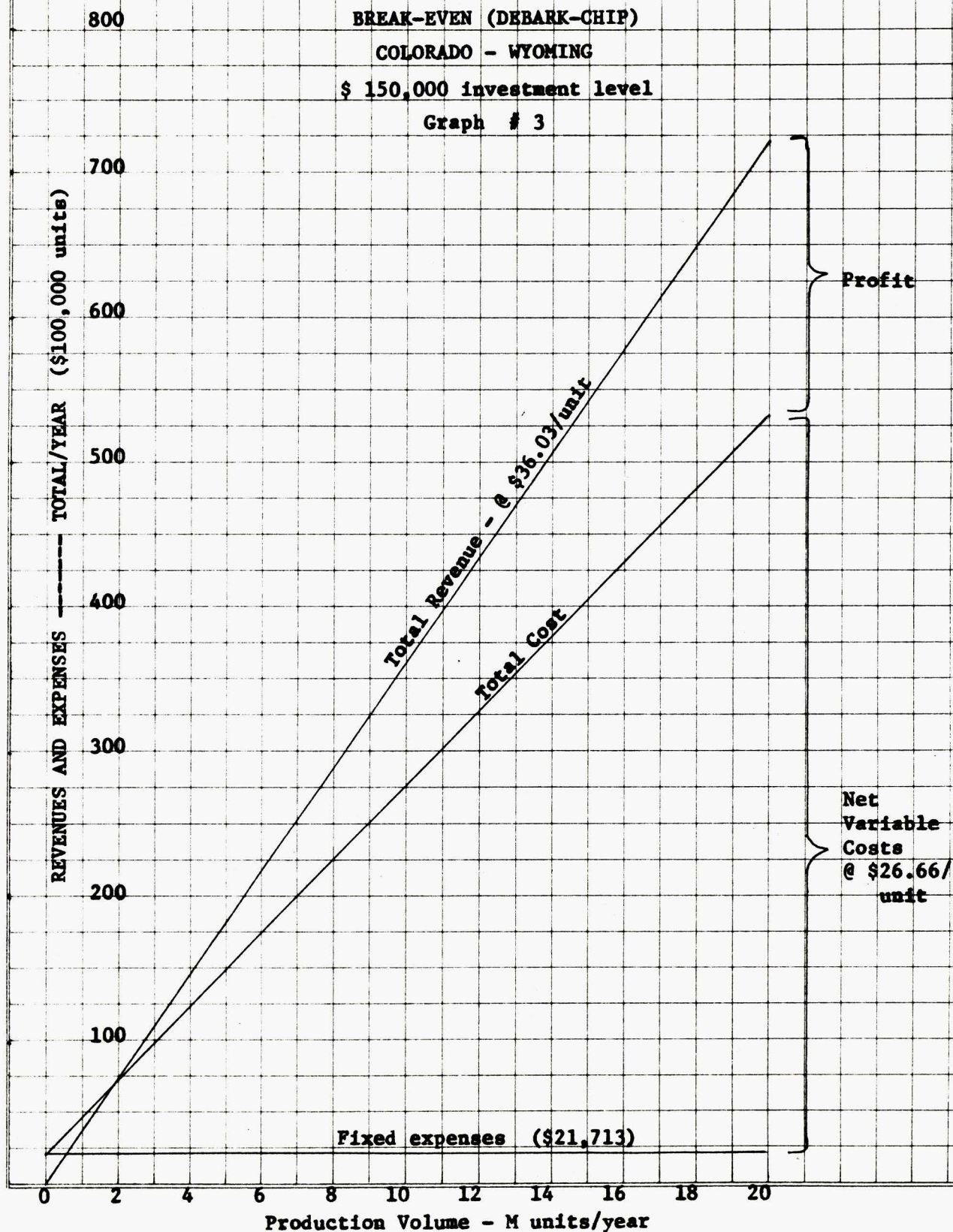
Fixed expenses (\$14,475)

Total Revenue - @ \$36.03/unit

Total Cost

Production Volume - M units/year

0 2 4 6 8 10 12 14 16 18 20



38

BREAK-EVEN (DEBARK-CHIP)

COLORADO - WYOMING

\$ 200,000 investment level

Graph # 4

REVENUES AND EXPENSES (\$100,000 units)

800

700

600

500

400

300

200

100

Profit

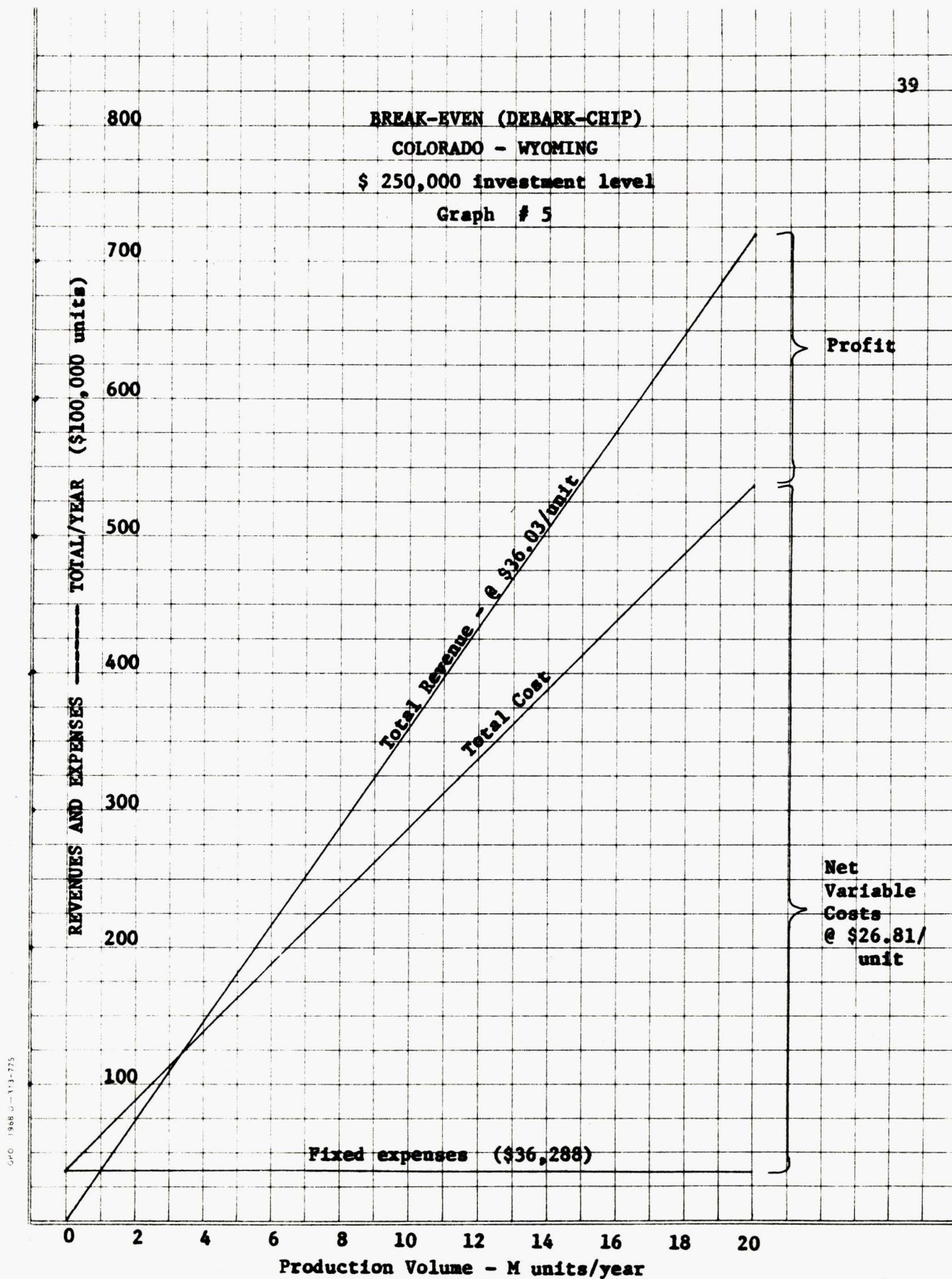
Net
Variable
Costs
@ \$27.33/
unit

Fixed expenses (\$28,951)

Total Revenue - @ \$36.03/unit

Total Cost

Production Volume - M units/year



40

800

BREAK-EVEN (DEBARK-CHIP)

BLACK HILLS

\$ 50,000 investment level

Graph # 6

700

REVENUES AND EXPENSES -- TOTAL/YEAR (\$100,000 units)

600

500

400

300

200

100

0

2

4

6

8

10

12

14

16

18

20

Production Volume - M units/year

(Probable
production
limit)

Profit

Total Revenue - @ \$39.31/unit

Total Cost

Net
Variable
Costs
@ \$24.56/
unit

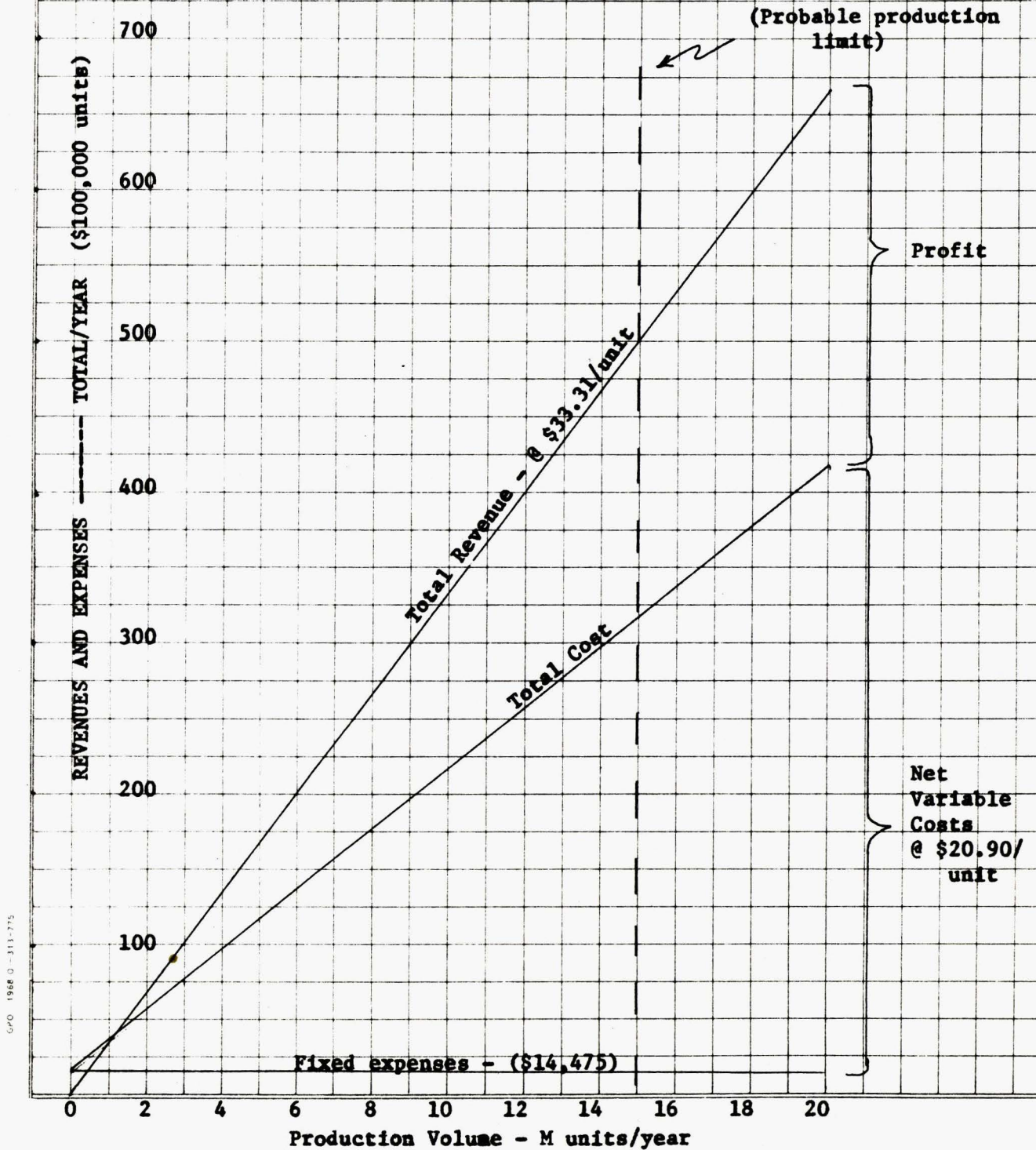
Fixed expenses (\$7,238)

BREAK-EVEN (DEBARK-CHIP)

BLACK HILLS

\$ 100,000 investment level

Graph # 7



42

800

BREAK-EVEN (DEBARK-CHIP)

BLACK HILLS

\$ 150,000 investment level

Graph # 8

REVENUES AND EXPENSES
TOTAL/YEAR (\$100,000 units)

700

600

500

400

300

200

100

0

2

4

6

8

10

12

14

16

18

20

Production Volume - M units/year

Total Revenue - @ \$33.31/unit

Total Cost

Fixed expenses (\$21,713)

Profit

Net
Variable
Costs
@ \$21.02/
unit

BREAK-EVEN (DEBARK-CHIP)

BLACK HILLS

\$ 200,000 investment level

Graph # 9

REVENUES AND EXPENSES — TOTAL/YEAR (\$100,000 units)

800

700

600

500

400

300

200

100

0

2

4

6

8

10

12

14

16

18

20

Production Volume - M units/year

Total Revenue - @ \$33.31/unit

Total Cost

Fixed expenses (\$28,951)

Profit

Net
Variable
Costs
@ \$21.69/
unit

44

800

BREAK-EVEN (DEBARK-CHIP)

BLACK HILLS

\$ 250,000 investment level

Graph # 10

700

600

500

400

300

200

100

TOTAL/YEAR (\$100,000 units)
REVENUES AND EXPENSES

Total Revenue - @ \$32.31/unit

Total Cost

Fixed expenses (\$36,288)

Profit

Net
Variable
Costs
@ \$21.17/
unit

Production Volume - M units/year